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SHEAR STRENGTH CAPACITY OF WIDE REINFORCED CONCRETE BEAM WITH SHEAR STEEL PLATES

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ABSTRACT

Wide reinforced concrete beams have been used in buildings to reducereinforcement congestion and floor heights for required headroom. The beamin most of these cases is wider than that of the supporting columns.Consequently their shear capacity might be effected and differ from that ofconventional beams. This project report presents the test results of four widebeam specimens in which their shear performances were studied. Theinfluence of the support widths (100% of the beam width), the arrangement offlexural reinforcement across the beam width, and the presence of shearreinforcement in the forms of third specimens consist of concrete with steelplate and control beam conventional beam were investigated. The test setupwas made similar for all the specimens, one pointed load were on the beamwidth, the load put at distance column (300mm*300mm) from the center ofsupport, therefore, the specimen control faed in diagonal tension shear. Butother specimens failed in flexural corporation. The results showed that widebeam with plate has no effect on the shear strength of concrete and theinfluence of concentrating the flexural reinforcement within the support widthhas no significant effect on the shear strength of concrete.

KEYWORDS: Distance Column (300mm*300mm), ACI (318-11), Flexural Reinforcement

INTRODUCTION

Reinforced concrete materials are widely accepted due to their strength, durability, reduced costs, quality, and easiness of formed into various shapes and sizes to make members like beams, slabs, columns, and shear walls. Concrete is strong in compression, but under tension it represents a poor behavior. Thus, steel which is able to present a good tensile behavior is added to concrete to improve The structural behavior of concrete members. In a concrete structure, beams would adequately resist the ultimate bending moments, shear force, and maybe torsion moments. Concrete slabs are mainly designed to withstand the most unfavorable arrangements of loads, in the same manner as beams. The use of reinforced concrete wide beams which in this study are shortly called wide beams is advantages formany reasons. Wide beams, with the normal aspect ratio of width over thickness of larger than (2), are utilized in buildings for the architectural gains, proportionally easy formwork, and lower depth, Wide beams are horizontal structural elements presenting multiple advantages when using for multistory building having generally larger openings and economical section, the disadvantages of wide beams with respect to the regular ones multi-story building having wide beams are used when complex optimization parameters are imposed. We make compare between many codes to find shear;

The following codes were used in the present study:

- ACI (318-11)
- EN 1992[9]
- Indian code IS 456-2000

LITERATURE REVIEW

Kulkarni (2009)the study is performed to elucidate more information and to understand the influence of critical parameters affecting the joint behavior such as column axial load, beam anchorage ratio, and wide beam participation

Dywany (2010)the results showed that the narrow support has no effect on the shear strength of concrete and the influence of concentrating the flexural reinforcement within the support width has no significant effect on the shear strength of concrete.

Bing and Sudhakar (2010)the studied behavior of the joints under the influence of critical influencing factors like column axial load, transverse beam, and beam bar anchorage ratio were also analyzed through the parametric studies.

Bing and Qian (2011) this study demonstrates that the repair of damaged RC beam-wide column joints by using FRP can restore the performance of damaged RC joints with relative ease, suggesting that the repair of beam-column joints is a cost-effective alternative to complete demolition and replacement.

Mohammadyan *et* al. (2012)the studied load carrying after first shear crack and displacement in wide beams using independent bent-up bars becomes larger in comparison to beams using other type's reinforcement that shows a gradual failure and more ductility.

MATERIALS & METHOD

General

Thischapter involves details of the experimental work carried out in these concerning specimen's details, type and properties of used materials, mixes details, molds, fresh and hardened tests, test procedure and measurements.

Experimental Program

The experimental program consists of testing four simply supported wide beams. All beams have the same dimensions and flexural reinforcement. They have an overall length of 1800 mm, a width of 560 mm and a height of 215 mm as shown in Figure 1 and they are designed to fail in shear.

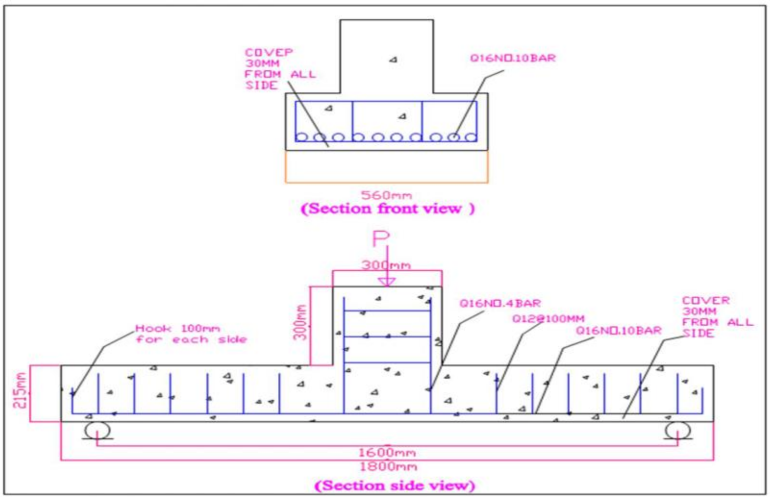

Figure 1: Typical Dimensions (mm) and Details of Tested Wide Beam

Materials

Cement

Ordinary Portland cement (type I) of Tasluja Factory (Iraq) is used in the present study.

Fine Aggregate

Al-Ukhaider natural sand is used in concrete mix.

Coarse Aggregate (Gravel)

Crushed gravel of maximum size 10 mm brought from Al-Niba'ee region (Iraq). Before using it, the sieve analysis is performed it, details are given below

Table 1: Grading of Coarse Aggregate (Gravel)

Sieve Size (mm)	%Passing by Weight	Limits of the Iraqi Specification[71] No.45/1984	Limits of ASTM[72] C33-03
12.5	100	100	100
9.5	87	85-100	85-100
4.75	15	0-25	10-30
2.36	4	0-5	0-10
1.18	0	-	0-5

Superplasticizer

In this work, the superplasticizer used is known commercially as (GLENIUM51) it is a new generation of modified polycarboxylic ether. It is compatible with all Portland cements that meet recognized international standards. Superplasticized concrete exhibits a large increase in slump without segregation. However, this provides enough period after mixing for casting and finishingthe concrete surface. Therefore, no retarders are required.

Steel Reinforcing Bars

Table 2: Properties of Reinforcing Steel Bars

Nominal Bar Diameter (mm)	Bar Area (mm^2)	Yield Stress (MPa)	Ultimate Stress (MPa)	Elongation at Ultimate Stress (%)
16 deformed	201	671	831	6.6
12 deformed	113	650	807	9.7

Water

Clean tap water of Diayla was used for mixing concrete. However, no test was carried out on the water to be used.

Concrete Mixing and Placing

Concrete Mixer

The concrete is mixed by using a horizontal rotary mixer with (0.1m) capacity available in the material construction laboratory, College of Engineering, Diayla University.

Table 3: Materials Required

Water	Gravel	Sand	Cement	Superplasticizer
35	1680	840	100	130
Kg	Kg	kg	Kg	Milliliter
0.35	16.8	8.4	1	

In this study used four Specimens all of Same dimension (1800*560*215mm).

The following observations were made.

- Compressive strength.

- Splitting tensile strength

All beams are tested in universal testing machine.

Figure 2: Compression Strength Test Cylinder Specimens

Figure 3: Failure of Cylindrical Specimen Due to Splitting

Figure 4: Preparation for Loading Test Machine

RESULTS AND DISCUSSIONS

General

In this study, four reinforced wide beam concrete specimens are tested. These beams are identical in length(L=1800mm)and width (W=560mm)and (H=215mm), tension steel reinforcement area (A_s=2000mm^2).but differ different in the shear reinforcement where(B1=steel plate in length,B2=steel plate in length with circular holes,B3=steel plate on width with circular holes,B4=reference)According to these variables, ultimate loads, load-deflection behavior, concrete compressive strain as well as crack patterns are different from each other, and these beam are divided into four specimens.

Behavior and Strength of Wide Beams

This test includes four beams designated as (BI, B2, B3, B4) which are similar in compressive strength (NSCC) and shear span to effective depth ratio (a/d = 0.31) but they differ in their shear reinforcement design. Beam (Bl) is considered as a reference beam of this group where in beam (B4), the increase in shear reinforcement ratio is studied, while in beams (B4) the presence of failed in shear by diagonal. As shown in figure (5) beams of this group failed in diagonal compression mode except beam (B4) by shear diagonal splitting mode. This different mode of failure was due to the use of gagger plate (4 mm) instead of (12 mm) bars of stirrups which have been used in other beams, where the inclined cracks do not penetrate into the shear zone due to the presence of this stiff gagger plate. Therefore, the crushing of concrete in the strut region is caused by reachingthe compressive stress in concrete to its ultimate value before yielding or rupturing these gagger plates. This behavior is clear in figure (5) where the main crack does not penetrate into the top face of the beam while the crushing takes place in the concrete strut especially at regions near the support. This type of failure (diagonal compression mode) makes the behavior more brittle. This means the necessity for determination of a maximum limit for shear reinforcement ratio to avoid brittle failure in wide beams. Further studies are required to reach values and equations to specify this limit.

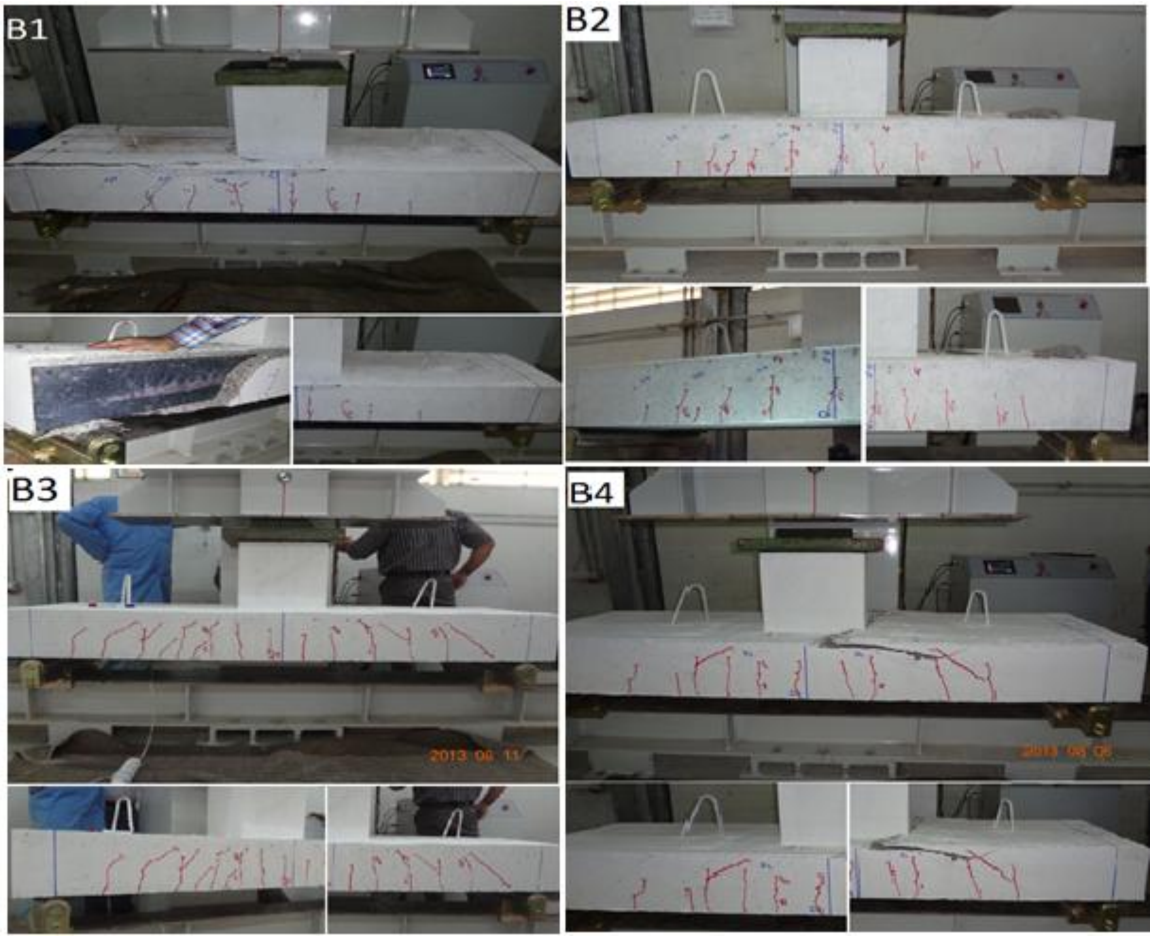

Figure 5: Crack Pattern after Testing Wide Beam (B1.B2.B3, B4)

The presence of gagger plates contributes in delaying appearance of cracks and hampers their development. It is clear in figure (5) where the cracks are few and short especially at the midspan of beams (B1) and (B2) and(B3) in comparison with crack pattern of beams (B4) .The results of cracking load (P_{Cr}) and ultimate load (Pu) for each beam of this group are illustrated in figure (6, 7, 8) These results indicate that the increase in the ultimate load from(420)kNto

(620)kNand an increase in cracking load from (60)kNto (70)kNand Reduce crack width from0.6mm in B4 to 0.13mm in B1 and 0.13mm in B2 and 0.20mm in B3.It was found that the ratio between crack width and ultimate load (P_{Cr} / Pu) is approximately constant in spite of the change in shear reinforcement.

Load-Deflection Response of Wide Beams

Testing procedure involves identifying the relation between the midspan deflection and the applied load for each beam. Figure 7 explains this relation for wide beams ofModels. It is clear that the relation is approximately linear throughout the entire path, but before failure the line slightly bends.

This behavior is observed in all beams due to controlling of shear rather than flexure in failure incidence especially small values of shear span to effective depth ratio (a/d) as is the case of these models. Also, the values of maximum deflection are generally small where they ranged between (8.4 mm and 18.37 mm). The figure shows (7) that the increase in shear reinforcement does not affect the general path of load deflection curve but increases the maximum deflectionaccompanied by the ultimate load.

This is because shear reinforcement has no effect on flexural rigidity, before the deflection seems to be approximately unaffected at all stages of loading. It can be noted that the reduce in shear reinforcement ratio reduce the shear capacity of beam leading to increment in deflection due to delay of failure which is governed by shear capacity of the beam.

From this figure, it can observe that the presence of steel plate enhances the Load - deflection curve characteristics. The presence of steel plate increases the area under the load-deflection curve i.e. increases the energy absorption capacity. Also at any load level, the deflection is smaller when the steel plates are present. The advantage of steel plate is more pronounced when used. This effectiveness of steel plate is due to two positive actions:

- Increasing the tension zone capacity of beam section and decreasing crack width and crack number in this region.
- Increasing the mechanical properties.

This will increase the compression zone depth depending on equilibrium of internal forces. This action causes an increase in moment of inertia of cracked section which increases the rigidity of the beam, there by the deflection becomes smaller.

Concrete Compressive Strain of Wide Beam

As shown in Figures (8) and, the solid wide beam (B1 and B2 and B3) show decreasing concrete compressivestrain in comparison with the reference beam (B4), where the study observe that maximum strain in B1=(8*0^{-4} mm) at ultimate load (471KN),and the maximum strain in B2=(7.3*0^{-4} mm)at ultimate load (420mm),and the maximum strain in B3=(11.7*0^{-4} mm) at ultimate load (620KN), and the maximum strain in B3=(12*0^{-4} mm) at ultimate load (460KN).

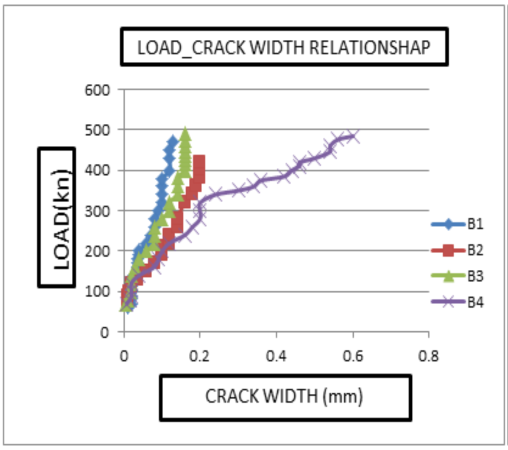

Figure 6: First Crack Development of Wide Beams Concrete

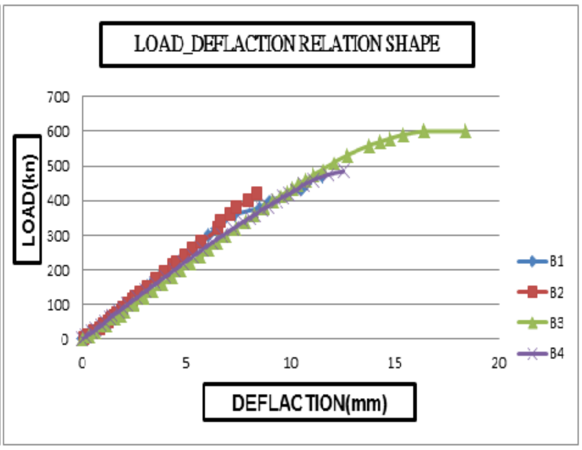

Figure 7: Load-Deflection Plot of Wide Beams

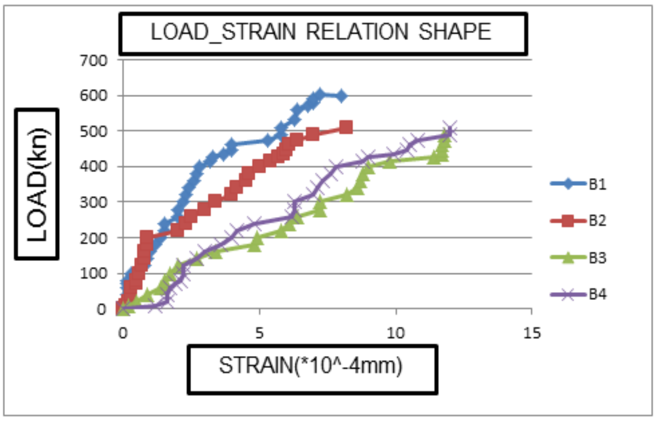

Figure 8: Load-Maximum Concrete Compressive Strain Curve of Wide Beams Concert

CONCLUSIONS

The following conclusions are drawn from the present study:

- Mid-depth of steel plate improves shear capacity of wide beam a little in comparison to other ways of reinforcing and the failure comes to be sudden failure under this kind of reinforcement.
- Using some steel plate causes increased shear capacity of wide beams significantly that in combination with stirrups there is increase in load capacity as well as ductility.
- Load carrying after first shear crack and displacement in wide beams using independent steel plate becomes larger in comparison to beams using other types of shear reinforcement that shows a gradual failure and more ductility.
- Using independent steel plate in wide beams that need a large number of flexural reinforcement provides anchorage feasibility and is mucheasier than providing stirrup legs in cross sectional area of these beams.
- Increasing the tension of steel reinforcement area of wide beam an increase of the ultimate load capacity by about (30% to 40%) is observed.
- The steel plate resistance to crack width where at load (420 kN) observes the crack width in (B1, B2, B3) equal to (0.12, 0.20, 0.16) mm respectively while (B1) controller spacemen equal to (0.46) mm.

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